Pitfalls in Endoscopic Ultrasound

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CONTENTS

Abstract

Endoscopic ultrasound (EUS) has a prolonged learning curve. Essential components include mastery of new endoscopic and radiographic skills as well as becoming familiar with anatomic relationships and variables. Additionally, providers must help train technicians and nurses, refine sedation strategies, and create productive relationships with cytopathologists. Aims of this chapter are to provide practical advice, hopefully to speed progression through the learning curve and to help improve safety and exam quality. Common EUS pitfalls and simple solutions are organized and presented in the following categories: sedation, endoscopic intubation and passage, orientation, technical issues, potential problem indications, choosing the right equipment for each case, and fine needle aspiration. Pitfalls are particularly salient for beginners, but many have pertinence for advanced endosonographers, including those moving to a new practice site. Selected take home points are highlighted with case examples and figures.

From: *Clinical Gastroenterology: Endoscopic Ultrasound*,
Edited by: V. M. Shami and M. Kahaleh, DOI 10.1007/978-1-60327-480-7_6,

Key Words: Pitfalls, Endoscopic orientation, Sedation, Intubation, Scope passage, Indications, Equipment, Ultrasound settings, Image quality, Fine needle aspiration, Coagulopathy, Endoscopy unit staff

SEDATION

Endoscopic ultrasound (EUS) examinations take longer and entail more noxious stimuli than standard upper endoscopy, especially when performed by beginners. Risk factors for sedation-limited exams should prompt precautions to minimize patient discomfort and obtain good outcomes. Heightened patient anxiety, alcohol or controlled substance use, and failure to tolerate prior endoscopy should be among a series of screening questions prior to exams. Additionally, severe cardiopulmonary disease warrants special consideration, such as seeking the assistance of an anesthesiologist.

Anesthesiology assistance and propofol are perhaps ideal solutions. When such luxuries are not available, more aggressive sedation initially with careful planning of exams to limit time and noxious stimuli may provide an adequate outcome. As an example, for a patient with a pancreatic head mass requiring tissue sampling, one strategy would be to apply a topical anesthesia block, achieve moderate sedation incorporating meperidine as a narcotic agent whenever possible, then pass the linear scope with fine needle aspiration (FNA) capability and proceed immediately to the appropriate EUS windows to begin tissue sampling. For such an exam, it would not be unusual to exceed 100 mg of meperidine and 8 mg of midazolam during 20–30 min of procedure time. Premedication, the addition of diazepam during exams, and adjunctive medication such as diphenhydramine are sedation strategies used by some providers. Adding inapsine (droperidol®) has fallen out of favor due to heightened concerns for QT prolongation and sudden death.

ENDOSCOPE INTUBATION AND PASSAGE

A major pitfall of EUS may be encountered when attempting to pass the echoendoscope. Several characteristics, including rigid and less rounded tips, oblique viewing optics, and larger diameters, can make this difficult. Intubation difficulties are less commonly encountered with newer generation scopes, featuring smaller diameters and more favorable tip configurations. Standard EGD neck positioning maneuvers are often helpful. A jaw thrust may allow easier esophageal intubation, particularly in patients where cervical spine disease precludes other positioning maneuvers. Unique solutions include partially inflating the

balloon on the echoendoscope and then applying a gentle torquing pressure (1). Another is to pass a standard forward viewing endoscope, then insert a guide wire and remove the scope. After the transfer of the wire through a catheter protecting the echoendoscope accessory channel, gentle traction can be applied on the wire during echoendoscope passage to achieve safe intubation (2).

Histories warranting special attention include prior difficulty passing endoscopes, dysphagia, and potential gastric outlet obstruction. Consider evaluating the anatomy and luminal integrity with a quick standard endoscopy exam. When necessary, dilation to at least 15 mm can be performed. For staging esophageal malignancy, a common indication requiring dilation, using hydrostatic balloons appears to be a safe option allowing complete EUS evaluations, including celiac lymph node sampling (3, 4). Maneuvers with a partially inflated EUS balloon or a guide wire, as mentioned previously, can also facilitate safe passage in some cases of luminal stenosis (1, 5). Use of a thinner caliber endobronchial ultrasound scope has been recently described to allow staging of celiac nodes in stenotic esophageal tumors (6). Some authors advocate high frequency probe use for stenotic esophageal tumors, avoiding the potential risks of dilation. Arguments against probe use include difficulties visualizing deeper tissue structures and the inability to perform FNA for confirmation of node status (7).

ORIENTATION

Probably, the most frustrating pitfall of EUS is becoming disoriented when learning to examine extraluminal structures, particularly when performing examinations in the duodenum. A good knowledge of cross-sectional anatomy with emphasis on vascular relationships is a prerequisite. An endosonographer can then follow the "roadmap" conferred by central arterial and mesenteric venous anatomy, serving as the frame of reference for many standard EUS views of surrounding structures. By convention, the aorta is positioned near 6 o'clock on the monitor, creating a situation where structures at 12 o'clock are anterior. From certain standard positions corresponding to anatomic landmarks, the examiner can coordinate exams and clarify pathology. Useful standard positions include:

(1) Esophagus at ~26 cm from the gums - aortic arch and aortopulmonary window slightly proximal to the carina;
(2) Proximal stomach ~40–45 cm from the gums - aorta giving off the celiac axis (Fig. 1);
(3) Duodenum distal to the major papilla - aorta closely associated with the uncinate process of the pancreas (Fig. 2);

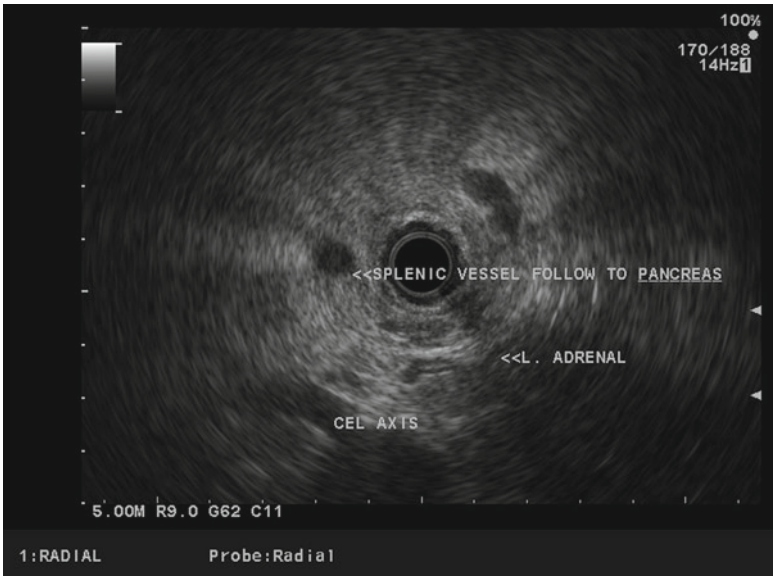


Fig. 1. Proximal stomach: aorta and celiac axis (cel axis) situated posteriorly. From this position, pushing slightly and angling the scope tip along the posterior wall of the stomach will bring the splenic vessels and body of the pancreas into view. The splenic vein is oriented along the inferior margin of the pancreatic body and tail.

(4) Rectum at ~7–9 cm insertion revealing the prostate in men and at ~9–11 cm insertion revealing the uterus in women (Fig. 3).

Of course, when anatomy has been surgically altered, visualizing structures may be difficult or impossible. An example is attempting to visualize the pancreatic head and common bile duct in a patient who has undergone distal gastrectomy and gastrojejunostomy.

Also remember that reproducing standard views of the gut wall and extraluminal structures involve more than putting the scope tip at the corresponding level of the gastrointestinal tract. With both radial and linear echoendoscopes, the ultrasound probe has to be positioned along a specific axis to convey a desired view. The axis necessary to generate standard views often changes little when imaging within linear organs such as the esophagus. In contrast, major scope tip adjustments may be necessary when imaging in the stomach and duodenum. Increasing numbers of examinations and familiarity with the anatomy will eventually relegate this concept to second nature. When learning, however, concentrating on standard positions to orient surrounding anatomy and pathology will help diminish uncertainty and frustration. For example,

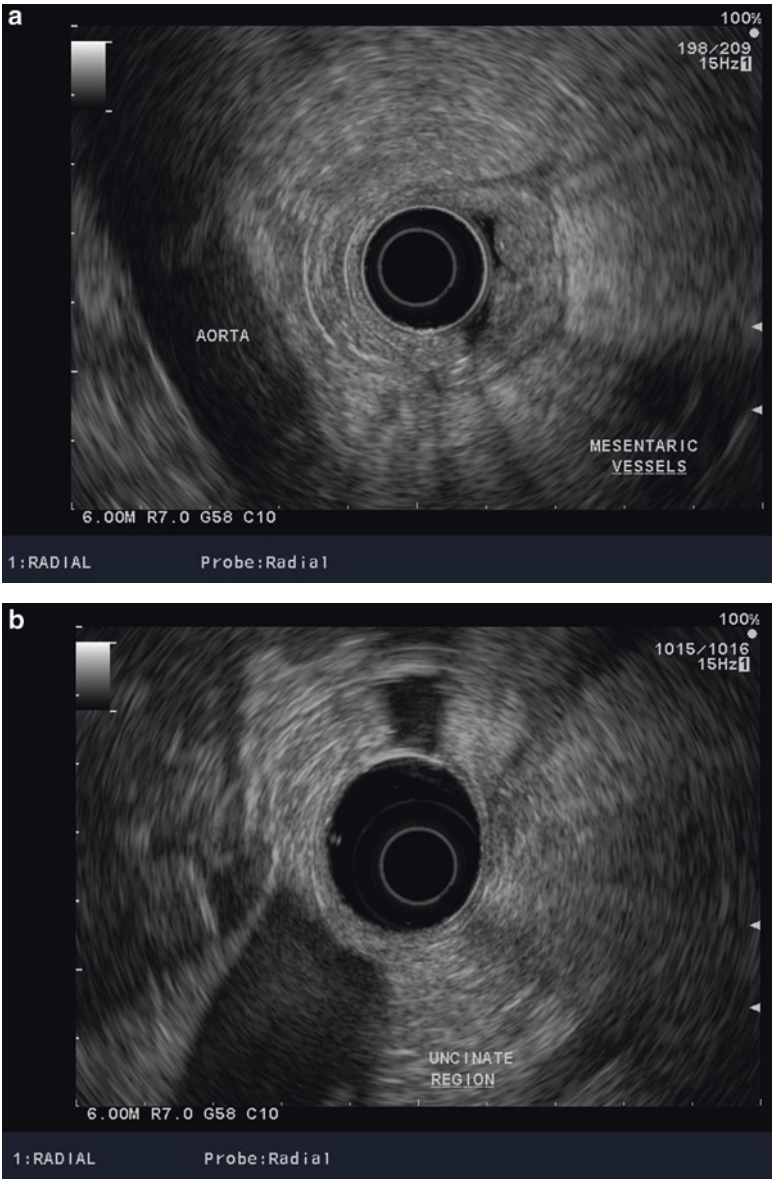


Fig. 2. (**a**) Deep duodenum: aorta with longitudinal view on the left side of the screen. The superior mesenteric vein and artery are often visible on the bottom right side of the screen. (**b**) Deep Duodenum: Aorta with cross-sectional view on the left side of the screen. The mesenteric vein may be seen deep to a portion of the uncinate process and pancreatic head on the bottom right side of the screen. (**c**) Mid Duodenum: Aorta with cross-sectional view highlighted by color doppler on the left side of the screen. The closely related common bile duct (CBD) and pancreatic duct (PD) may be visible on the bottom of the screen before they join at the major papilla.

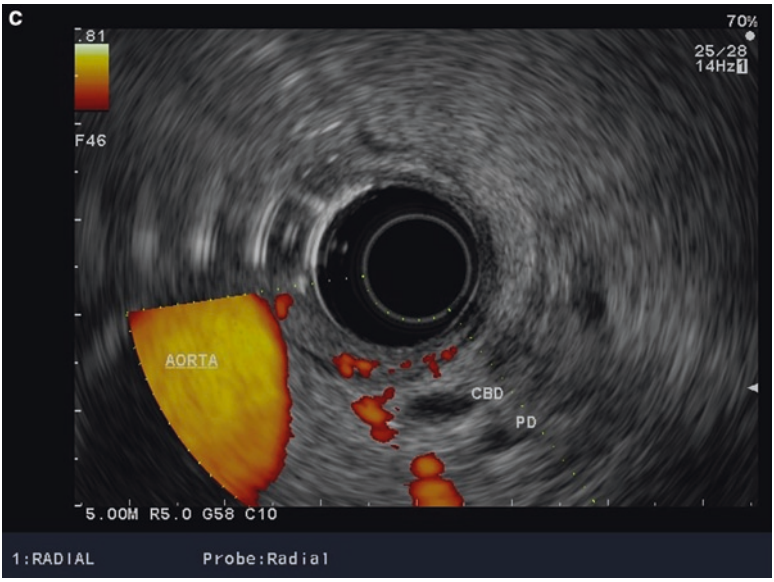


Fig. 2. (continued)

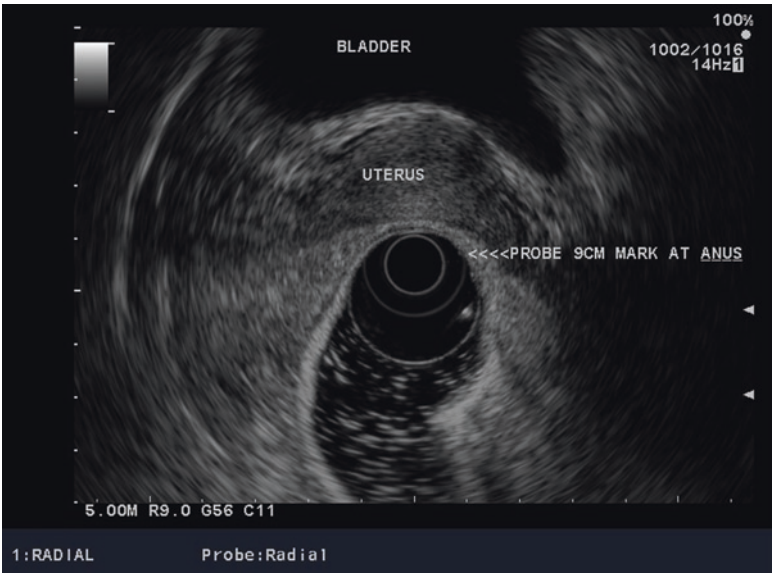


Fig. 3. Female rectum: 9 cm proximal to the anus with the uterus immediately anterior and the bladder deeper to the rectal wall. These structures can be oriented along the top of the screen to establish the anterior reference for the remainder of the exam.

the aorta and celiac axis are good starting points when attempting to evaluate the body of the pancreas. From the celiac axis, pushing distally should bring the body of the pancreas into view, with the splenic vessels and splenoportal confluence framing the gland along its inferior margin. Pitfalls associated with this particular maneuver include: the deeper celiac axis precluding adequate visualization, and a proximal gastric configuration where the scope lodges at the fundus-body junction instead of sliding along the greater curve. Solutions include using appropriate tip deflection and torque: downward deflection while attempting to visualize the deep celiac axis and upward deflection with rightward torque to follow the greater curve distally.

TECHNICAL ISSUES

There are a few technical solutions to improve image quality. Acoustic coupling is an important ultrasound concept particularly relevant to EUS, as the transducer is often in an air-filled lumen. Because ultrasound waves do not penetrate air, eliminating air from the equation is imperative. Air elimination begins before the scope is passed, while testing the balloon covering the ultrasound transducer. The water bottle attached to the scope should be full. Ensure the balloon is completely filled with water and aspirated several times while manipulating air bubbles toward the suction port in order to expel them. In the patient, the balloon should be filled with water to varying degrees at nearly all stages of the EUS exam. Care should also be taken to minimize insufflation of air through the scope and to suction air from the lumen of the GI tract whenever possible. Even after appropriate precautions, air bubbles within the scope balloon may be an issue limiting exams. Options include withdrawal of the scope to attempt to clear the bubble(s) followed by repeat passage, or proceeding with the image field defect and compensating by scope tip manipulations precluding interference with the anatomic view of interest.

In patients with a history of significant latex allergy, it is not recommended to use standard endoscope balloons for acoustic coupling. In such cases, water instillation into the lumen may be used to "submerge" the ultrasound transducer and replace air in the lumen. Water instillation is also useful when attempting to generate detailed views of the gut wall layers, such as clarifying small subepithelial lesions and staging ampullary neoplasms. Remember that water instillation into the upper GI tract is an aspiration risk. Position the patient appropriately and use oral suction diligently. On this note, be cognizant of the aspiration pitfall during any upper EUS exam, particularly in patients with potential gastric outlet obstruction or after induction of deeper sedation.

EUS systems have variable control settings to obtain better quality images. Until providers gain the depth of knowledge created by supplemental reading and experience, complex manipulations of the system settings should be avoided while in search of the perfect image. Routinely performing complex manipulations potentially wastes time and may force a trip by a company ultrasound technician to reset the system. There are a few controls that are standard with all systems and easy to manipulate. Among these are the frequency settings. Low frequencies increase the ability to resolve structures at greater distances from the transducer (such as a lesion deep in the liver), while high frequencies increase the ability to resolve structures close to the transducer (such as gut wall layers). Magnification is another control, and conveys maximal image detail of a point of interest at a given distance from the transducer. Finally, gain and contrast settings allow focusing and the ability to adjust brightness. Keep in mind that even when settings are properly utilized, some structures are harder or impossible to clearly image in certain patients. An example is the pancreas that cannot be differentiated from surrounding tissues because it is infiltrated by fat, appearing brighter than usual and amorphous. In this instance, anatomic landmarks such as vasculature are helpful.

EUS INDICATIONS

Failure to understand diagnostic limitations of EUS can result in pitfalls. Most of these pitfalls are avoidable if limitations are understood and discussed with patients and referring physicians prior to examinations. Although EUS may heighten diagnostic accuracy, it is important to note that EUS providers should not overlook the clinical history and standard radiographic data. Even more critical, EUS is not a substitute for histology. For example, when attempting to identify the etiology of nonhealing gastric ulceration or thickened folds of the stomach, the absence of muscularis propria expansion and perigastric lymphadenopathy may reassure against malignancy, but standard endoscopic biopsy information and surveillance may still be indicated. It is perilous to perceive EUS as able to "rule out" cancer in this situation. Another example is a patient with abdominal pain, weight loss, and a limited quality computerized tomography (CT) scan revealing fullness of the pancreatic head. In this scenario, a hypodense expansion of the pancreatic head on EUS could be secondary to malignancy or pancreatitis. Even if fine needle aspiration (FNA) is performed, there may be false negative sampling errors or nondiagnostic samples (8, 9). Furthermore, sampling acute pancreatitis with or without fluid collections may confer additional risks, including

infectious complications (10, 11). The full history with supporting lab data and perhaps a better quality pancreatic protocol CT scan as a surveillance measure may be indicated. In some cases, surgical exploration should be considered if the history and CT findings are consistent with a malignant process, even if the FNA results are reassuring.

In summary, a thorough clinical history and good quality radiographic data are essential for proper case selection and to help formulate more accurate EUS impressions and recommendations. Sometimes, proper evaluation of data obtained noninvasively will prevent unnecessary EUS exams, or allow EUS to be delayed in order to maximize the clinical utility and safety of the exam.

For tumor staging, several pitfalls are important to keep in mind, as data may be paramount to oncology team members' treatment decisions regarding resectability and neoadjuvant therapy. One important pitfall is overstaging due to tumor inflammatory changes, particularly when attempting to differentiate between T1/T2 and T2/T3 lesions. Understaging lesions is also a potential problem, often when dealing with early node metastasis where the nodes are subcentimeter and less abnormal appearing (12, 13). Difficulty predicting vascular involvement of the mesenteric vessels in pancreatic cancer staging is another pitfall (14, 15). Staging after chemotherapy and radiation therapy is inaccurate because EUS cannot distinguish tumor from scarring (16). A repeat exam after neoadjuvant therapy, however, can sometimes be helpful to reassure against persistence of widespread nodal disease and new metastatic disease (17). An example would be an older patient, with locally advanced esophageal cancer and marginal performance status, who has completed neoadjuvant therapy and apparently has stable disease by repeat CT and positron emission tomography (PET). CT scans and PET scans may have difficulty characterizing lesions less than one centimeter, particularly metastatic lymph nodes in this size range, although this is an evolving topic (18–20). If a repeat EUS exam with FNA proves that multiple locoregional nodes remain diseased, this poor prognostic information may affect the decision to proceed with surgery. Even more importantly, if metastatic disease were proven by FNA in the celiac or cervical regions after neoadjuvant therapy, most centers would not proceed with surgery.

EQUIPMENT SELECTION

Choosing the appropriate equipment for the particular indication can avoid pitfalls. Probes are often useful for intramural lesions and superficial cancers to provide T-staging information while radial exams have been

advocated to help detect locoregional lymphadenopathy, particularly for esophageal and rectal cancer (21, 22). Linear scopes have advantages resolving extra luminal structures such as liver lesions and in visualizing vascular involvement by tumors. Furthermore, linear scopes are necessary for tissue sampling to heighten metastatic disease staging accuracy or provide definitive diagnosis of deep wall lesions such as gastrointestinal stromal tumors (23, 24).

In general, linear scopes should be used when the etiology is strongly suspected by cross sectional imaging and tissue sampling is the indication for the exam. A clear example is a patient with back pain and weight loss, positive serum tumor markers, and a pancreatic body mass encasing the celiac axis and SMA. A less clear example arises in esophageal cancer staging, particularly when confronted with a moderate stenosis and the need to clarify upper abdominal node status. Initial use of the linear EUS scope will expedite definitive tissue sampling and may be safer if the compromised esophageal lumen is crossed only once with an EUS scope and sedation is limited. However, omitting the radial exam may compromise staging accuracy, and it is possible that FNA will not be indicated during the exam.

Some complicated disease processes may benefit from radial exams, particularly when cross-sectional imaging suggests the normal anatomy may be obscured and/or there has been a significant time interval since the most recent cross sectional imaging. In such cases, radial exams confer the benefit of a 360° view, which may facilitate EUS interpretation, particularly for radiologists and surgeons using EUS data to facilitate clinical decision-making. Examples include pancreatic and gallbladder mass lesions in patients with recent clinical histories consistent with inflammatory etiologies.

Endoscopy unit efficiency is also a consideration when choosing equipment. An example is thickened gastric folds or small superficial appearing gastric wall lesions. If an EUS probe is applied, it can clarify a need for deeper wall sampling attempts or mucosectomy. The endoscope necessary to perform these maneuvers is already in position. Savings may include exam and equipment reprocessing time.

FNA CONSIDERATIONS

Bleeding risks and management of anticoagulants are often debated in the periprocedure period. Data suggest that bleeding complications are rare, but appear to have a higher incidence when sampling cystic lesions and pancreatitis (25). More recent publications and societal guidelines emphasize that antiplatelet agents may be safely continued

for many therapeutic endoscopy procedures, including polypectomy and dilation (26, 27). Providers should attempt to make evidence-based decisions as data evolve. At present, it appears that a strict policy of several days off antiplatelet and anticoagulant medications before or after FNA procedures should be reconsidered in patients at high risk for cardiovascular events. Often, continuing monotherapy with either aspirin or another platelet inhibitor may be an option. Heparin and/or coumadin may be safely restarted immediately after the procedure if there are no signs of postprocedure complications. Prudent endosonographers should involve cardiologists and primary physicians in patients at higher risk for periprocedure cardiovascular events. Avoid the pitfall of standardized written or verbal instructions to stop platelet inhibiting medications and coumadin five days prior to procedures or delay the use of these agents after procedures.

Passage of the FNA sheath through the scope once in position can be compromised by angulation of the scope tip. Few things are more frustrating than spending 10 min locating a pancreatic head lesion, only to be stymied by the inability to advance and lock the FNA sheath in place. Corrective measures include losing position by straightening the scope tip to pass the device, or using a more flexible FNA sheath and needle. Penetration of the GI wall while maintaining visualization of the target may also be difficult. Corrective actions include opposing the scope tip more completely against the wall with an upward control deflection after suctioning all air from the lumen followed by a quick forceful thrust with the needle as opposed to a slow and controlled push. If these measures fail, the stylet may be pulled back, so only the sharp bevel of the needle is presented against the wall. Removal of the stylet during needle passage increases the probability that lesion samples will be contaminated by gut epithelium. Finally, a 25-gauge needle may allow easier puncture of the wall layers and access to a lesion, while maintaining EUS visualization.

Poor visualization of the needle may also result if aiming adjustments are made by turning the tip of the scope right or left to bring a target into view. Avoid this pitfall by using torque on the scope, instead of the right and left turn dial, as the linear EUS array will provide a better view of the needle path to the target. A bent FNA needle may be very hard to visualize en route to the target, and the easiest adjustment is to replace it with a new apparatus. Although more flexible sheaths and needles, as previously mentioned, are tremendous assets to ease passage through scopes, they are more easily bent. Adjusting the scope tip position so less elevator lift is required to hit the target will help prevent “crooked arrow” mishaps, and is also likely to decrease costs (Fig. 4).

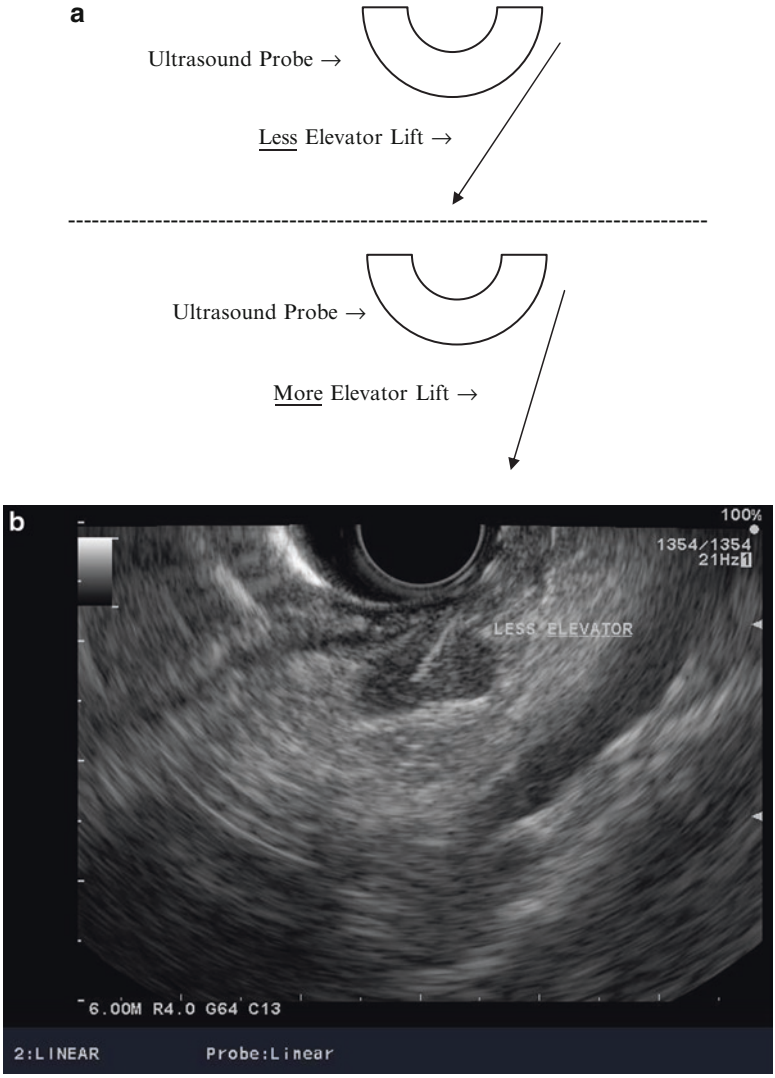
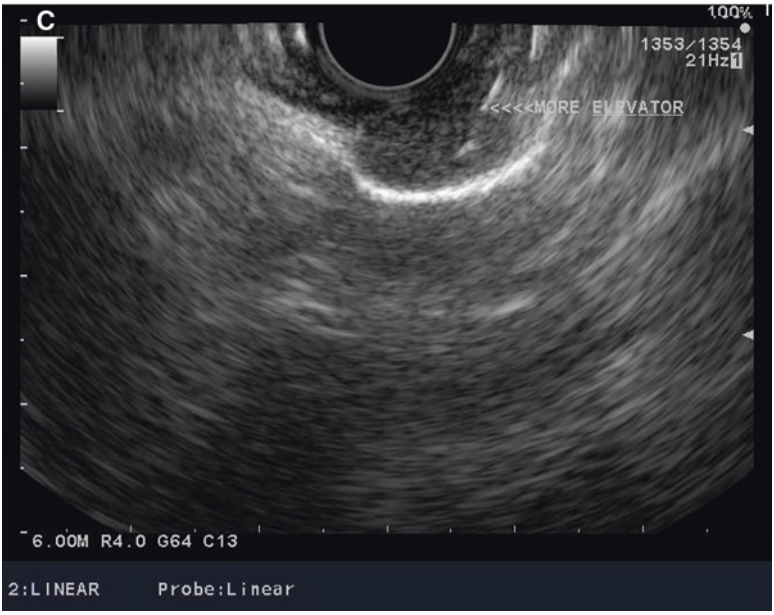


Fig. 4. (**a**) Targeting lesions: Note the angle between the center of the EUS probe and the needle. This angle is influenced by variables, including the depth of scope insertion, degree of tip deflection toward the target, and the amount of elevator deflection on the needle sheath. (**b**) Mediastinal node sampling with less tip deflection toward the target and less elevator pressure on the needle sheath. (**c**) Same mediastinal node but sampled with more tip deflection toward the target and more elevator pressure on the needle sheath. (**d**) Bent FNA needle sheath resulting from more elevator pressure in targeting a lesion.



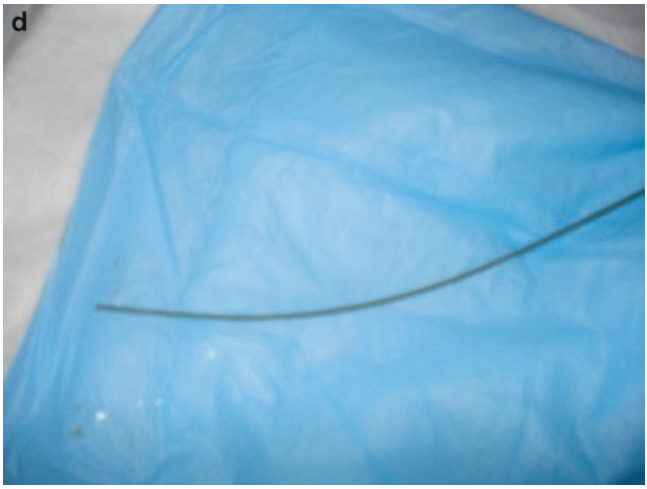


Fig. 4. (continued)

In order to mitigate the nondiagnostic pitfalls of FNA, form a good working relationship with cytology staff. It has been clearly shown that the presence of cytopathology staff on-site to assist in preparation and interpretation of specimens will increase diagnostic FNA accuracy

(28–31). The minimum possible number of FNA passes can be obtained in this fashion, which may decrease procedure time and complications. Additionally, there will be less need for repeat sampling procedures. Because physical presence is less cost-effective for billing by cytology staff, it has been debated whether having on-site cytopathology interpretation is more cost-effective in general (32, 33). For endosonographers, patients, and third party payers, it appears clear that on-site cytopathology preparation and interpretation is optimal practice (34).

Endoscopy unit staff requirements may also depend upon the relationship that is established with cytopathology. Equipment setup and processing combined with patient care typically require both an endoscopy technician and endoscopy nurse for EUS FNA procedures, even if an anesthesiologist or CRNA is involved. If a cytopathologist and/or cytopathology technician is actively involved with slide preparation, endoscopy unit staffing requirements may be less rigorous.

CONCLUSION

In summary, pitfalls of EUS are many and varied. Concentrating on patient specific and equipment-related issues will be particularly beneficial to those learning EUS. Providers concerned with endoscopy unit management should thoroughly consider select topics, including sedation, equipment choice, and FNA. Hopefully, most pitfalls in practice will not feel as deep after reviewing this chapter, promoting less frustration and greater satisfaction for practitioners employing this exciting technology.

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